California Water and Environmental Modeling Forum

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Calibrating DSM2-QUAL Dispersion Factors with Practical Salinity

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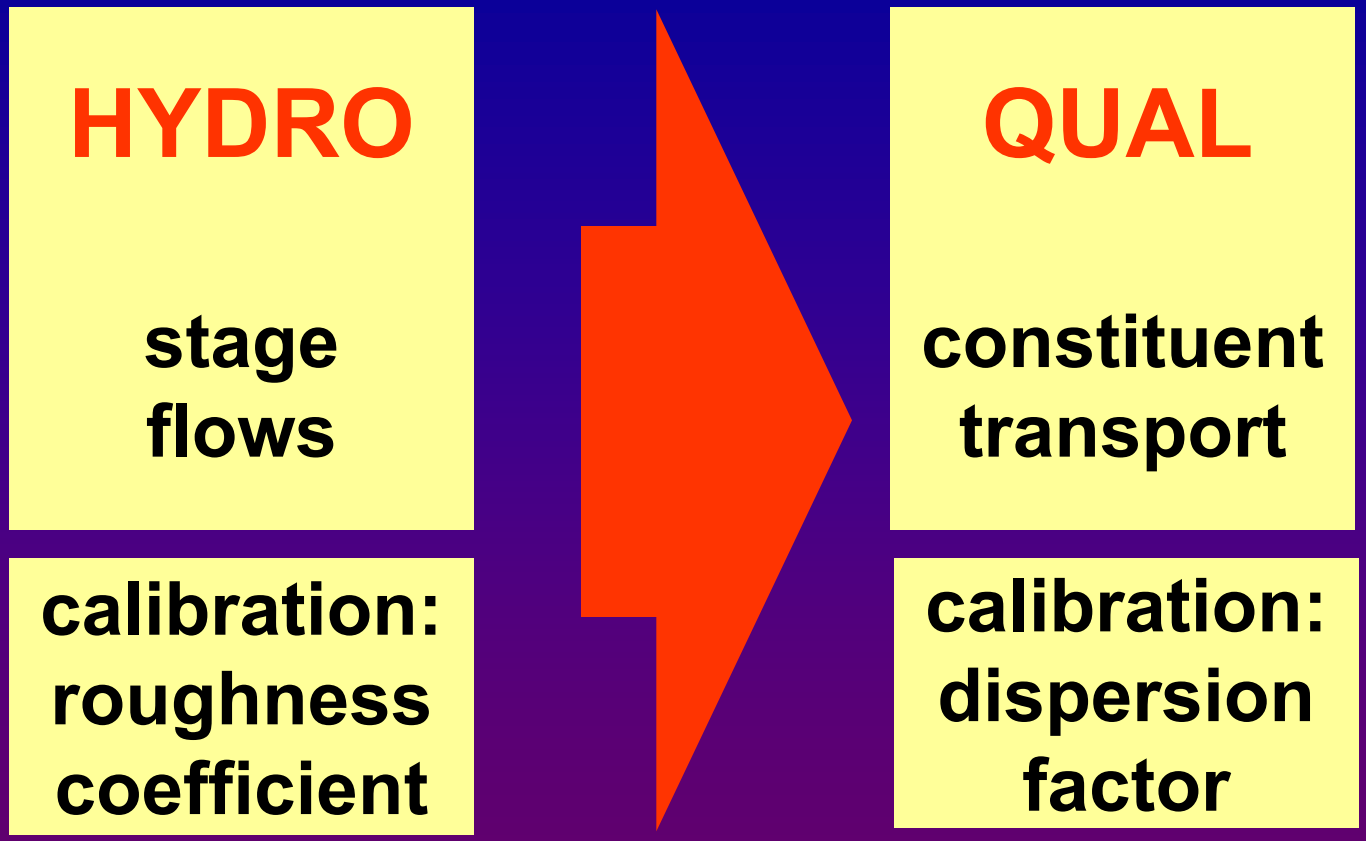
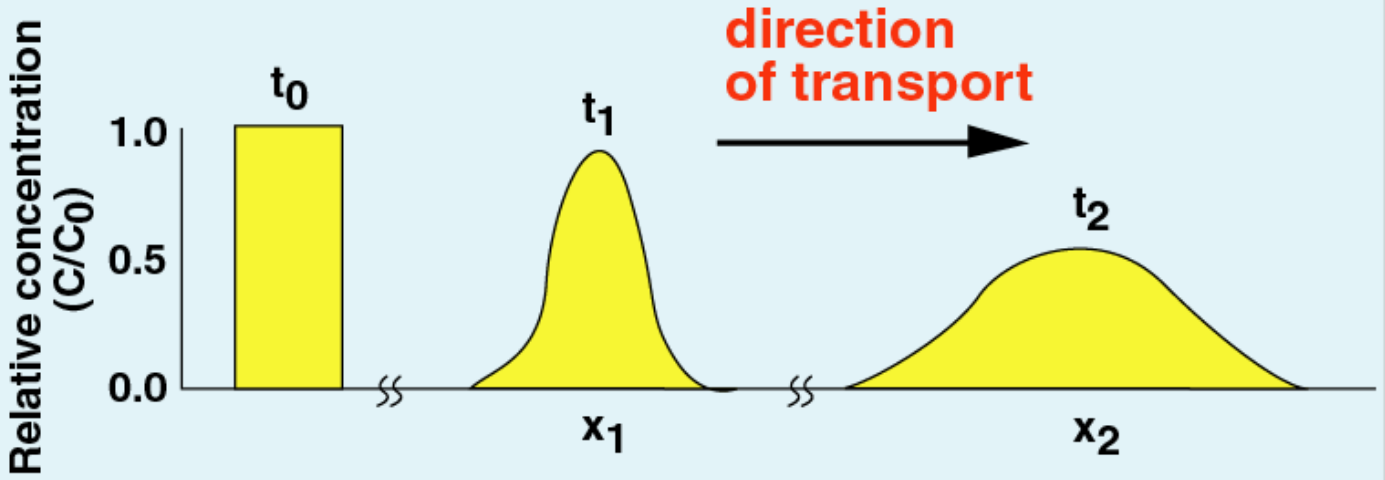
Outline

- Dispersion & calibration
- Salinity & EC
- EC concerns with QUAL
- Practical salinity & the Delta
- Possible calibration/simulation scenario

Modeling Sequence



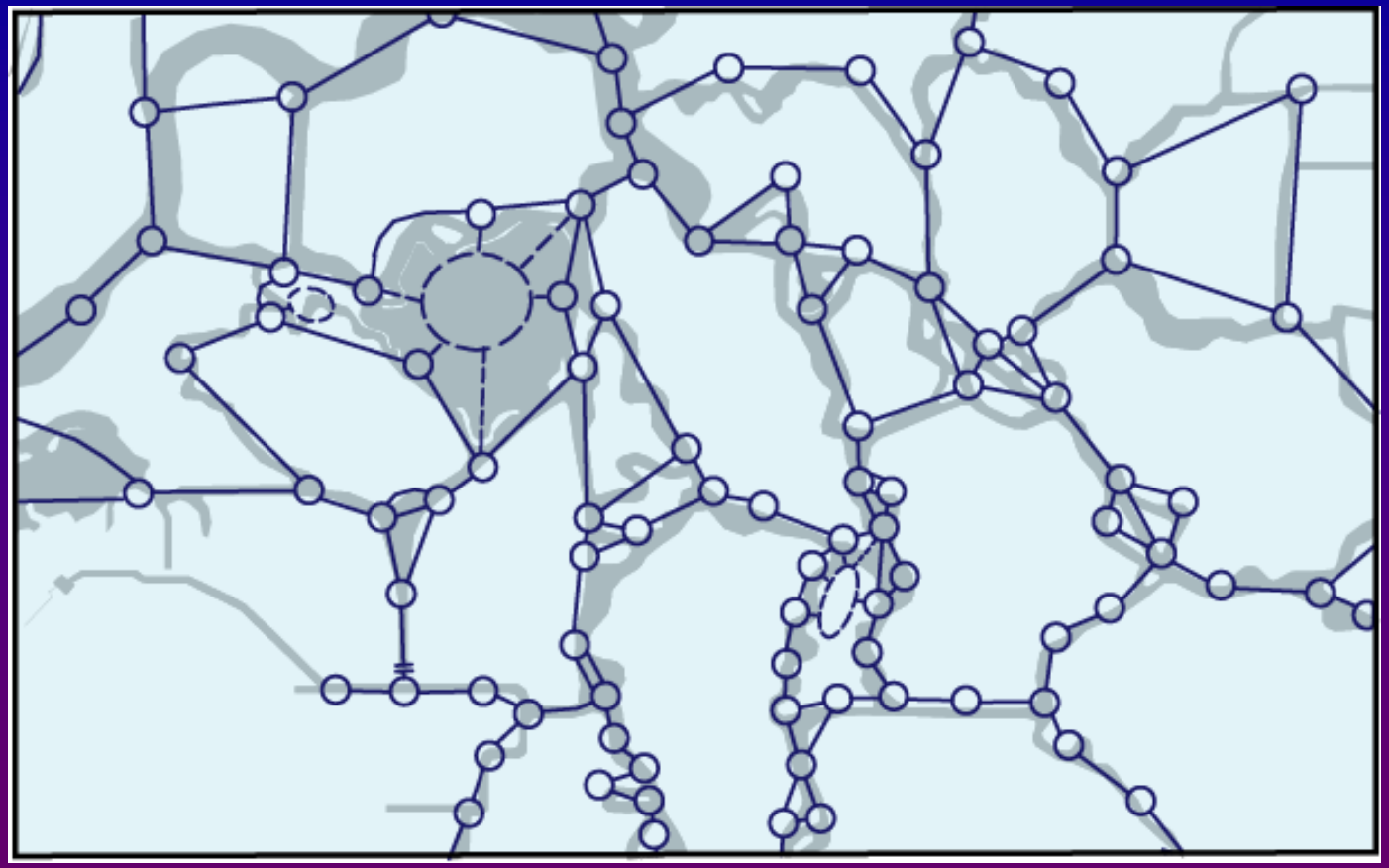
Transport and spreading of conservative solute slug



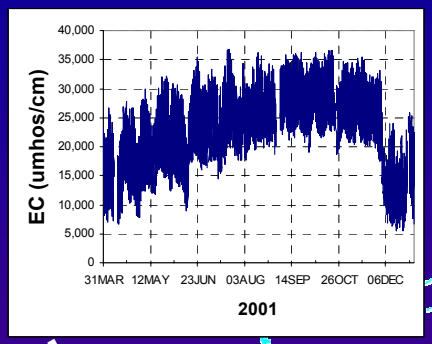
Advection bodily moves solute without causing distortion.

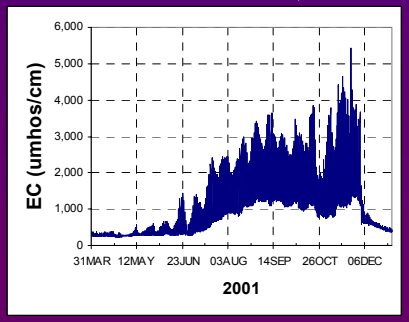
Dispersion due to vertical velocity shear arising from bed friction: turbulent diffusion disperses solute.

DSM2 Grid in Central Delta



Calibrating QUAL
(Setting Dispersion Factors)





1) Simulate historical hydro-dynamics.

2) Transport constituent using initial dispersion factors.

3) Adjust dispersion factors until modeled constituent matches with interior observations.

Move inland and focus on dry periods with high EC.

Salinity

- def: *the total amount of dissolved material in grams in 1 kg of (sea) water.*
- TDS often used to indicate salinity, but
  - **Doesn't measure volatile material**
  - **Chlorides can be lost in drying**
- Electrical conductivity (EC) related to ionic concentration
  - Precise & allows frequent and remote sampling

Why Calibrate with EC

- Abundance of historical data exists
  - Spatially
    (boundaries and internal locations)
  - Time domain
    (frequency and extent)
  - Martinez available

- Often want to simulate EC for studies

Past Modeling Strategy with QUAL

Calibrate dispersion factors with EC using historical period

- Develop EC for ag drainage
- Use historical EC in the Delta

Model hypothetical EC given Delta hydrology

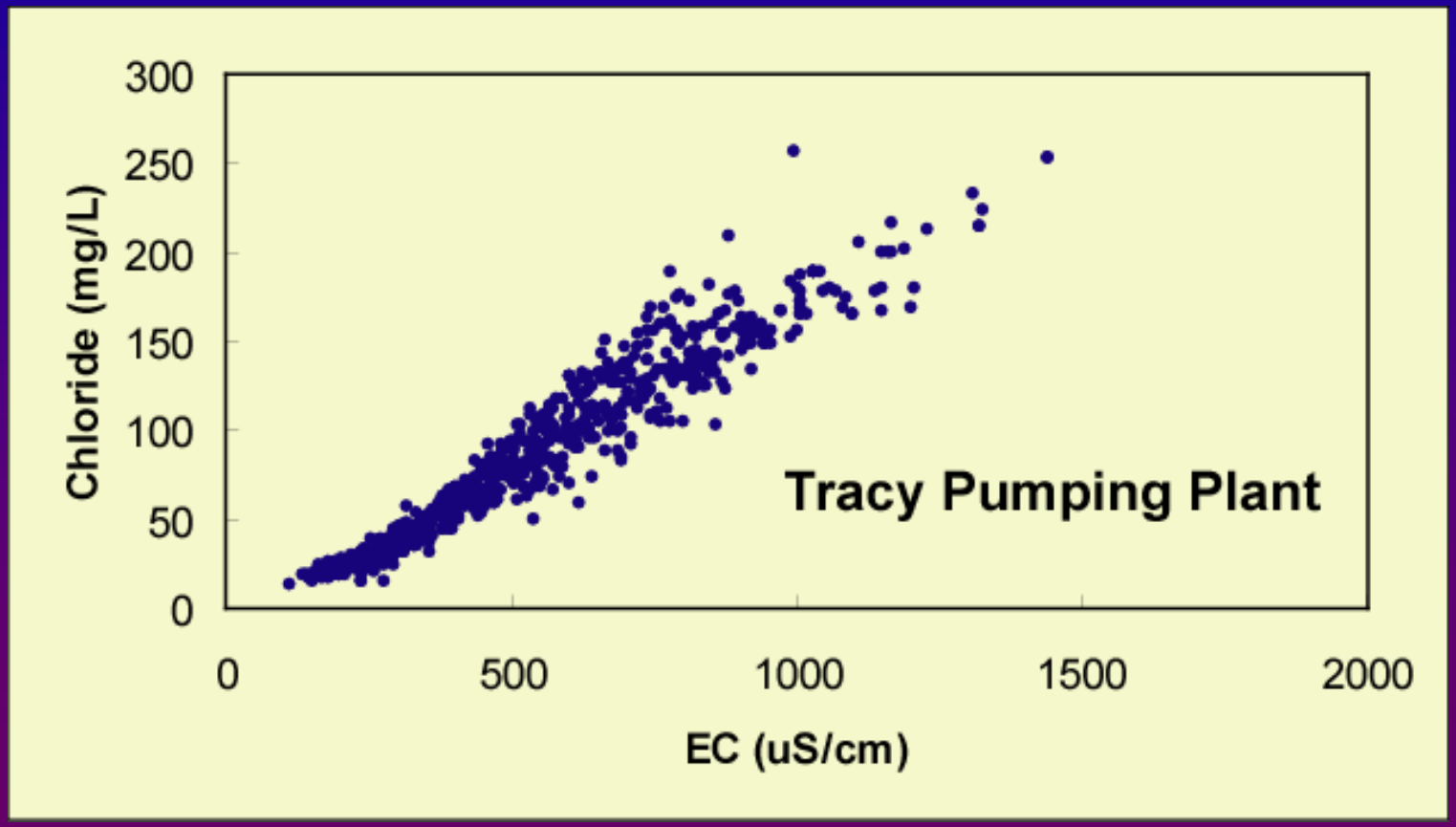
- Develop flow-EC relationships
- Develop EC for ag drainage
- Convert results of simulation to other constituents

Model constituent of interest directly given Delta hydrology

- Develop constituent values at boundaries
- Develop constituent values for agricultural drainage

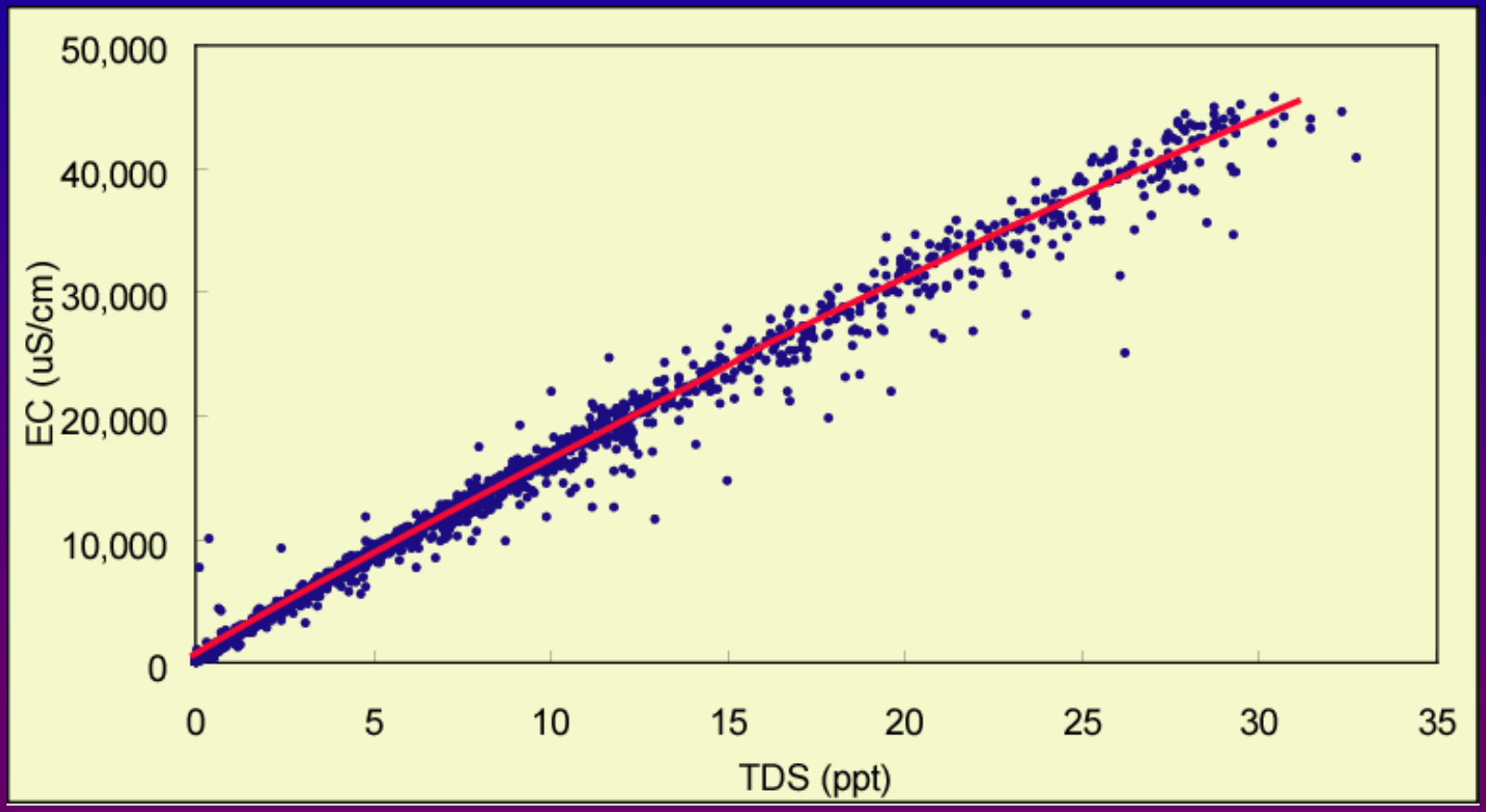
EC Concerns in Simulations

EC – constituent relationship may be source-dependent



EC Concerns in Simulations

EC underestimates salinity at high concentrations



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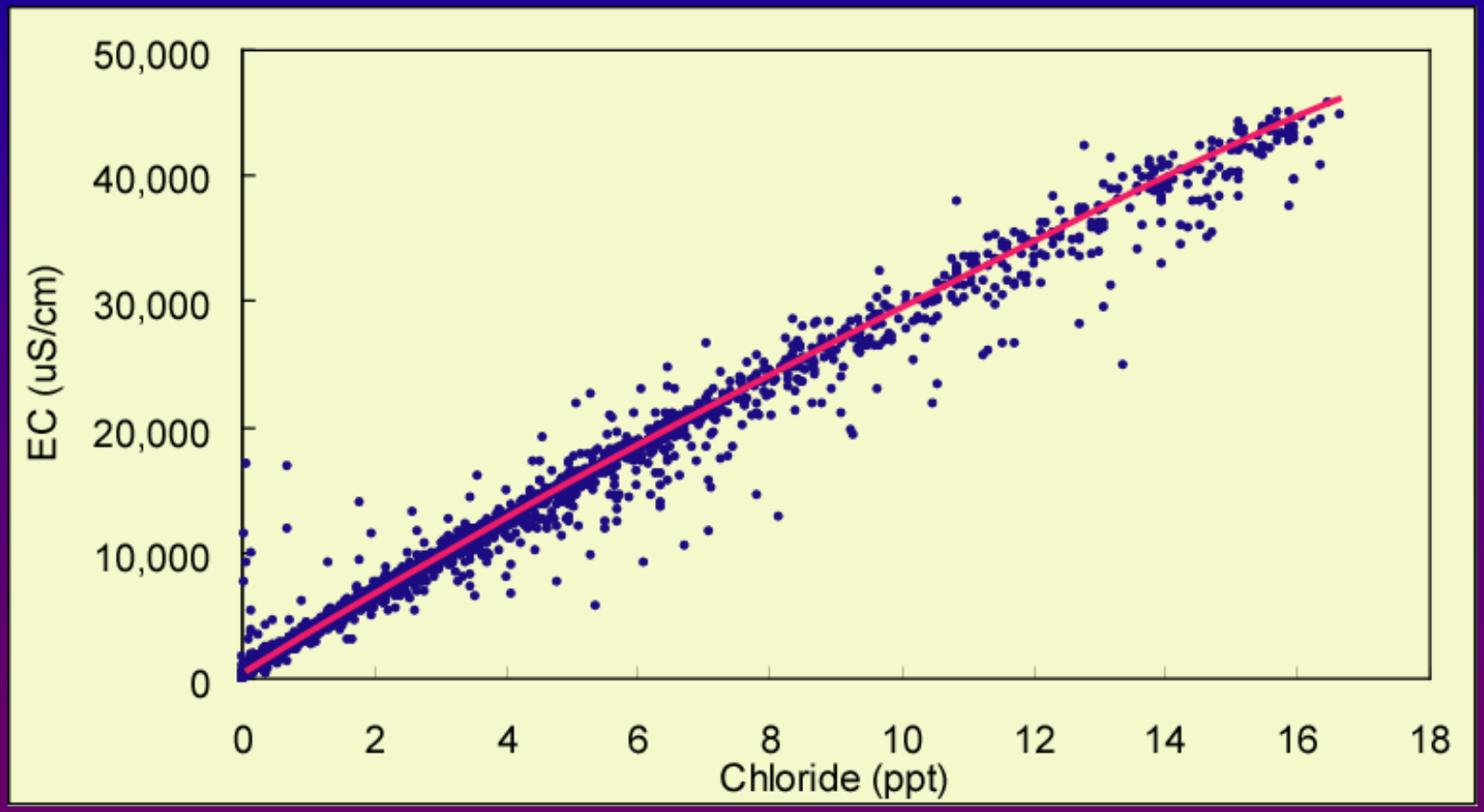


EC Concerns in Simulations

If simulation in EC & results reported in EC – OK, but:

- **Simulating EC, then converting to other constituent may need caution.**
- **Simulating conservative constituent using dispersion factors calibrated to EC may bias results high.**

Desired Conservative Constituent for Calibrating Dispersion Factors

- EC-based
- Display linear relationship with TDS (salinity)

One Possible Approach

- Convert historical boundary and internal Delta data from EC to TDS.
- Calibrate to TDS.

Practical Salinity

- Calculated relationship between measured EC and salinity.
- Salinity values derived from dilutions or concentration of standard sea water.
- Temperature and pressure dependent.

Practical Salinity Scale 1978

Lewis, E. (1980). "The Practical Salinity Scale 1978 and Its Antecedents." *Journal of Oceanic Engineering*. OE-5, 1.

Schemel (2000) simplified practical salinity, S, for 25 ºC:

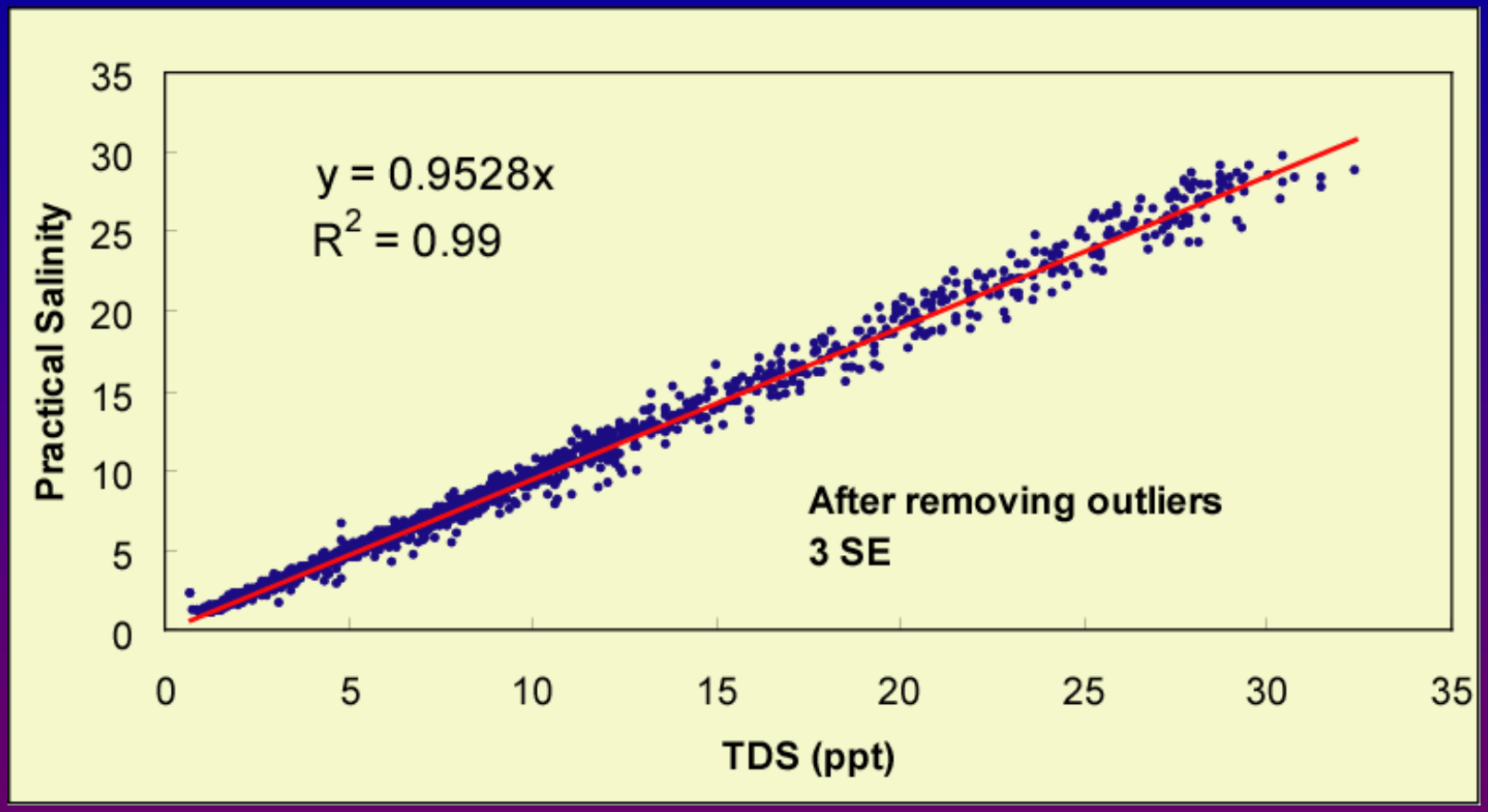
$$S = K_0 + K_1 R_T^{1/2} + K_2 R_T + K_3 R_T^{3/2} + K_4 R_T^{2} + K_5 R_T^{5/2}$$

where

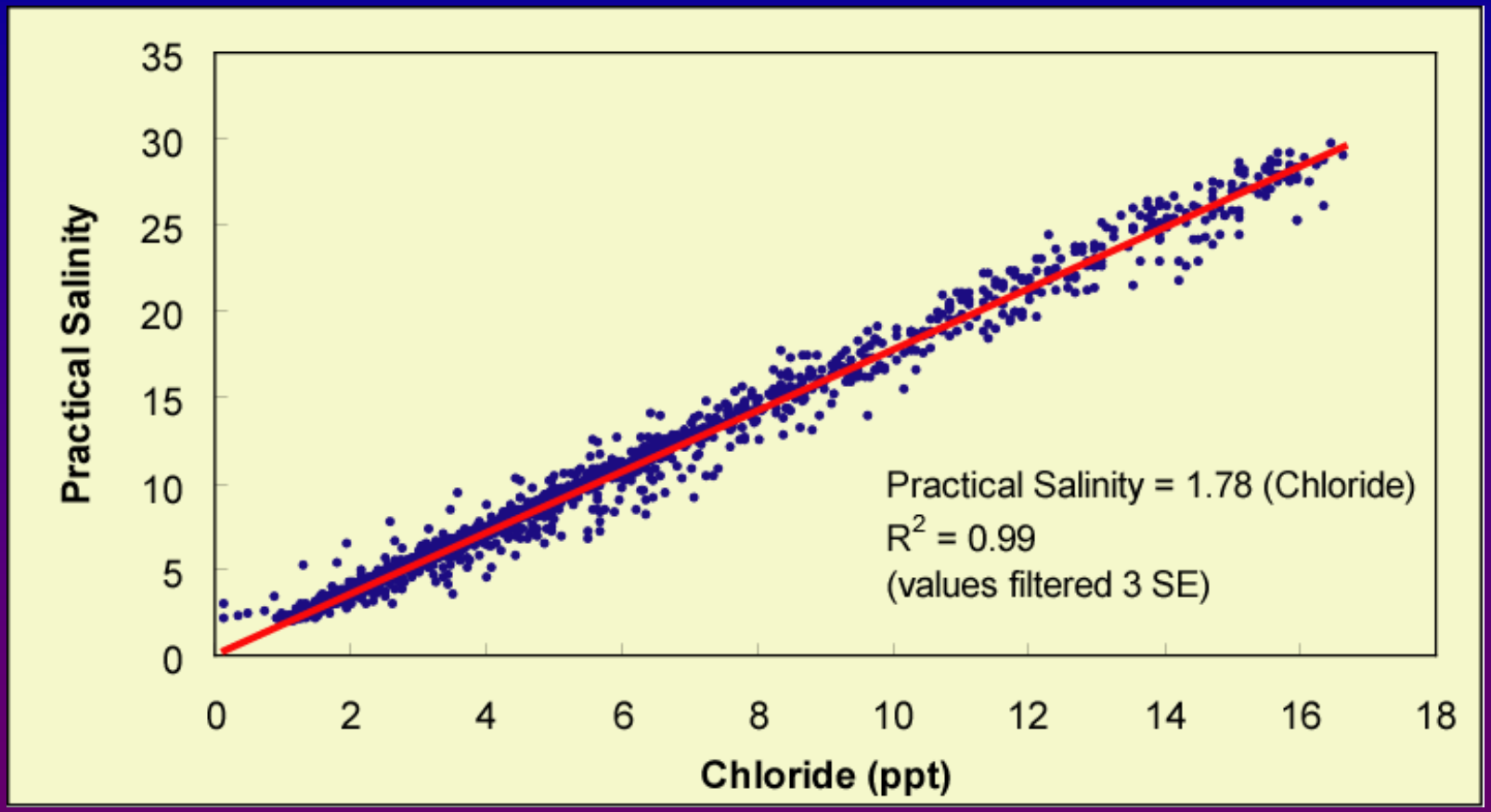
$$R_T = \left(\frac{EC_{sample}}{EC_{seawater}} \right)_{@\,25^{o}C}$$

Practical Salinity Scale 1978

Practical Salinity vs Observed TDS



Practical Salinity vs Observed Chloride

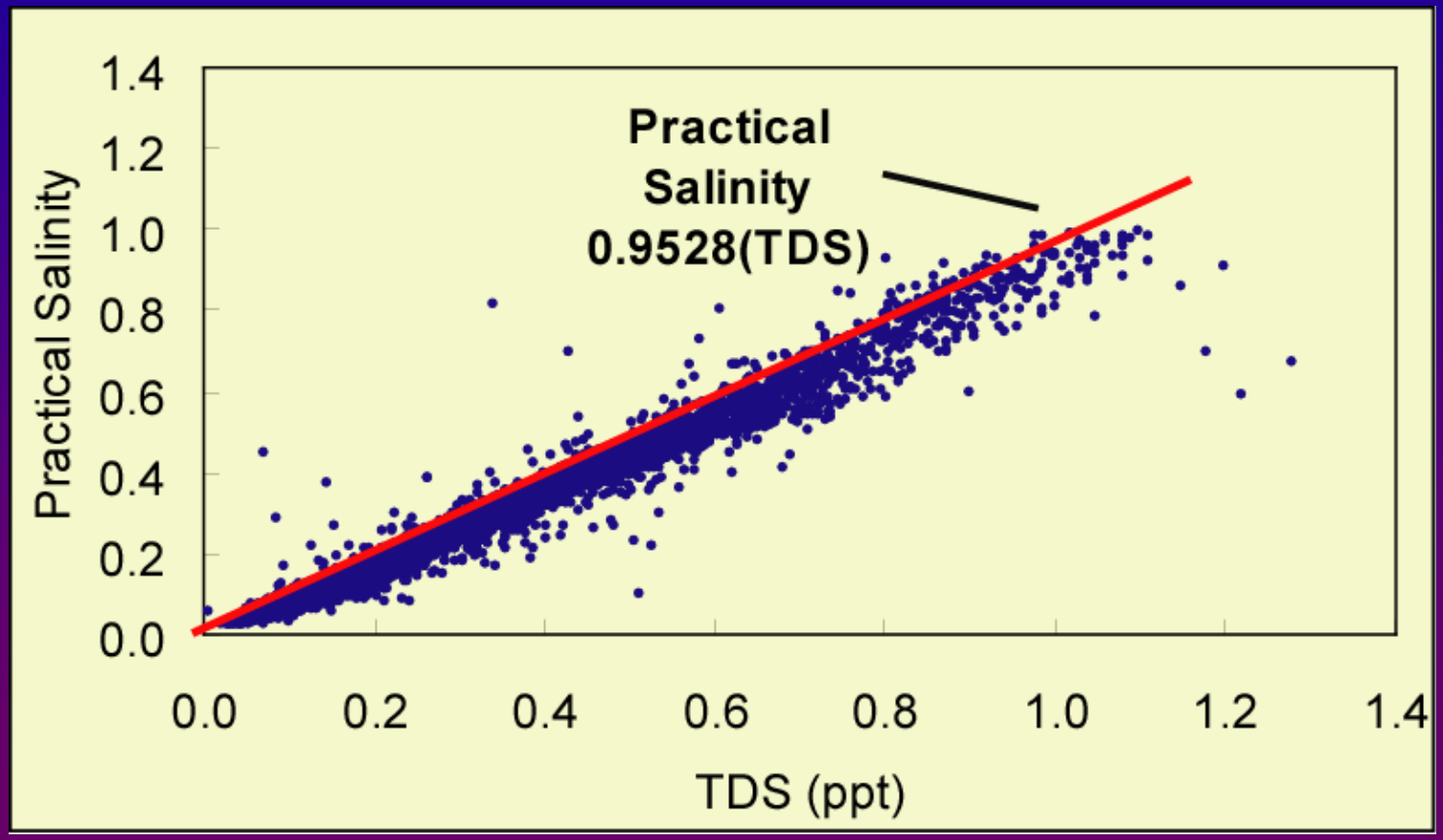


Practical Salinity Caveats

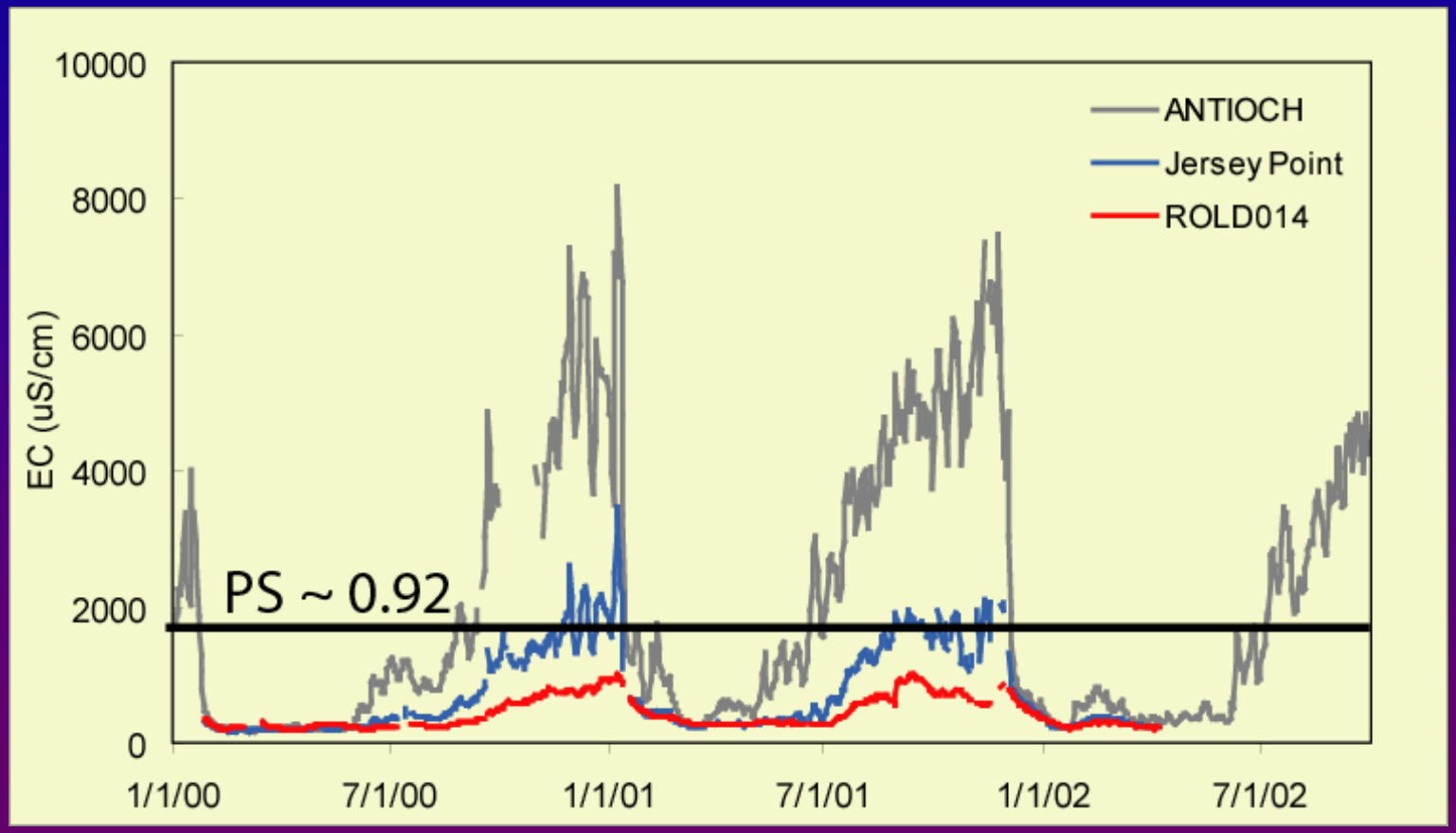
- As originally derived, valid only down to 2 (~3,800µS/cm)
- A (small) standard correction down to 0 salinity exists based on dilutions with distilled water.
- Variable treatment in literature for estuarine environments.
- Need for development of estuarine-specific corrections for low salinity.

Low Practical Salinity in the Delta

Hill et al. (1986) found that land based salts display a different behavior (Delta samples deviate below 1 psu).



Delta EC: 2000, 2001



Treatment of Low Practical Salinity

American Public Health Association

Can use standard correction with some limitation.

USGS

Apply standard correction to in situ EC collected in Bay-Delta as part of standard Methodology

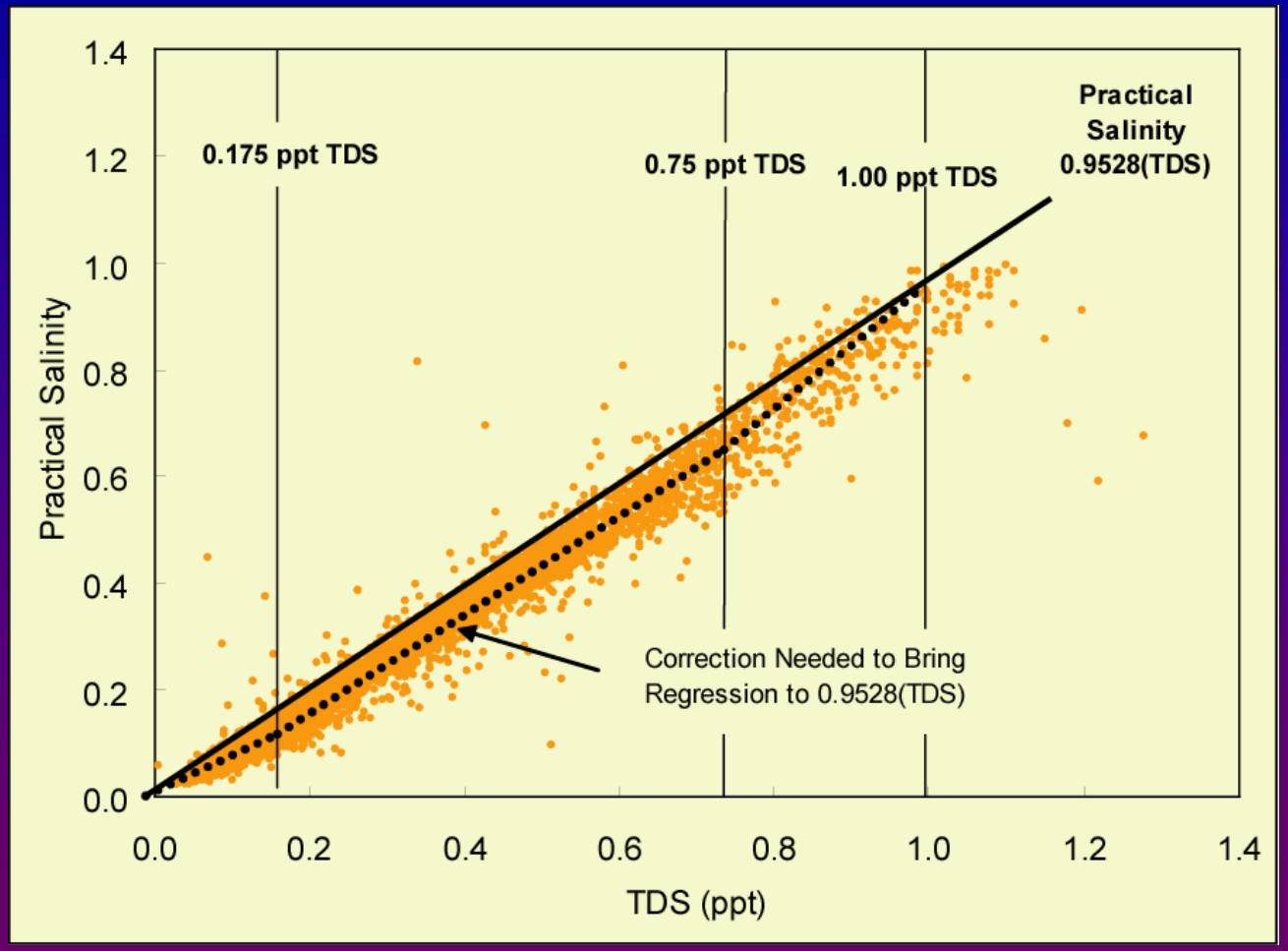
Seabird

No correction needed if EC corrected to 25^{o}C

Hill & Woods

Standard correction not applicable to water influenced by land–derived salts.

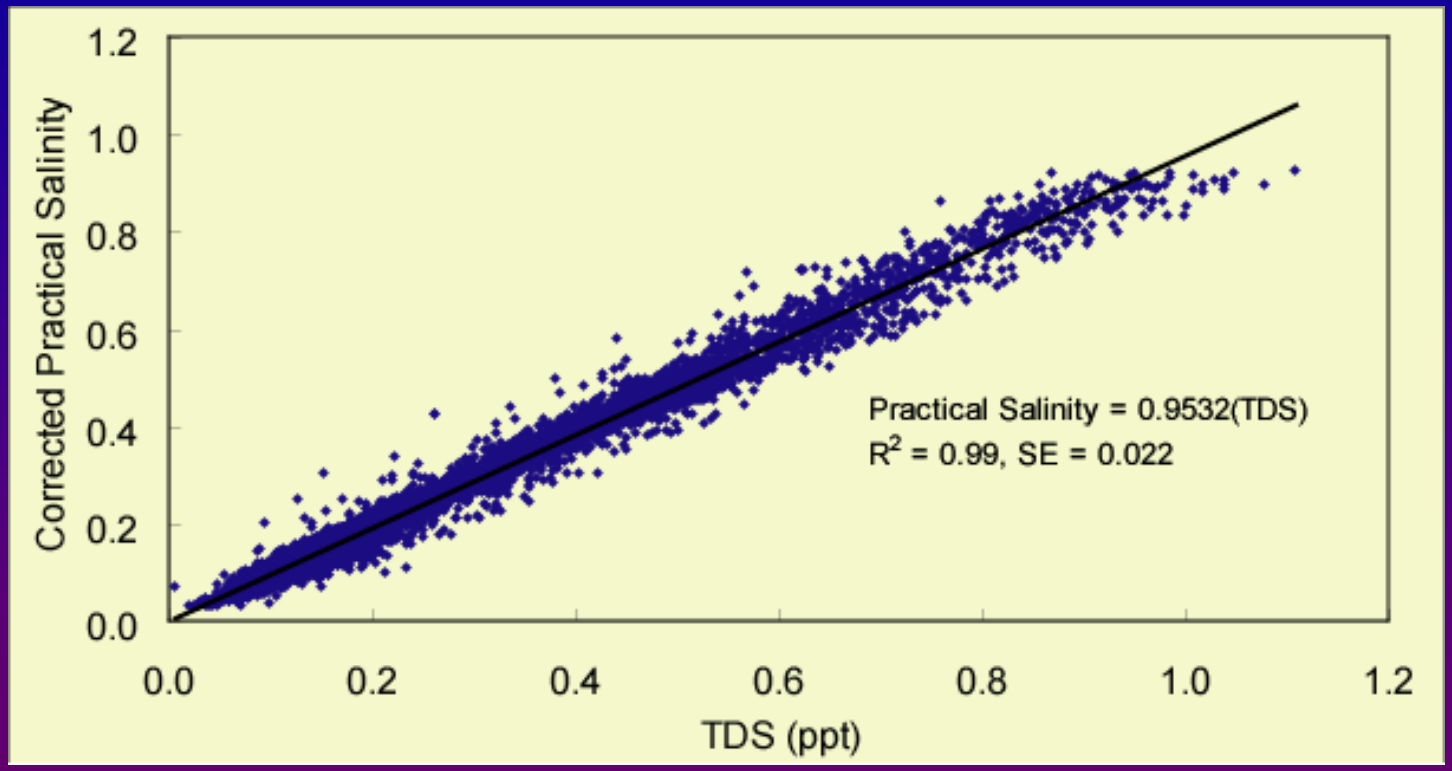
Correcting Low Delta Practical Salinity



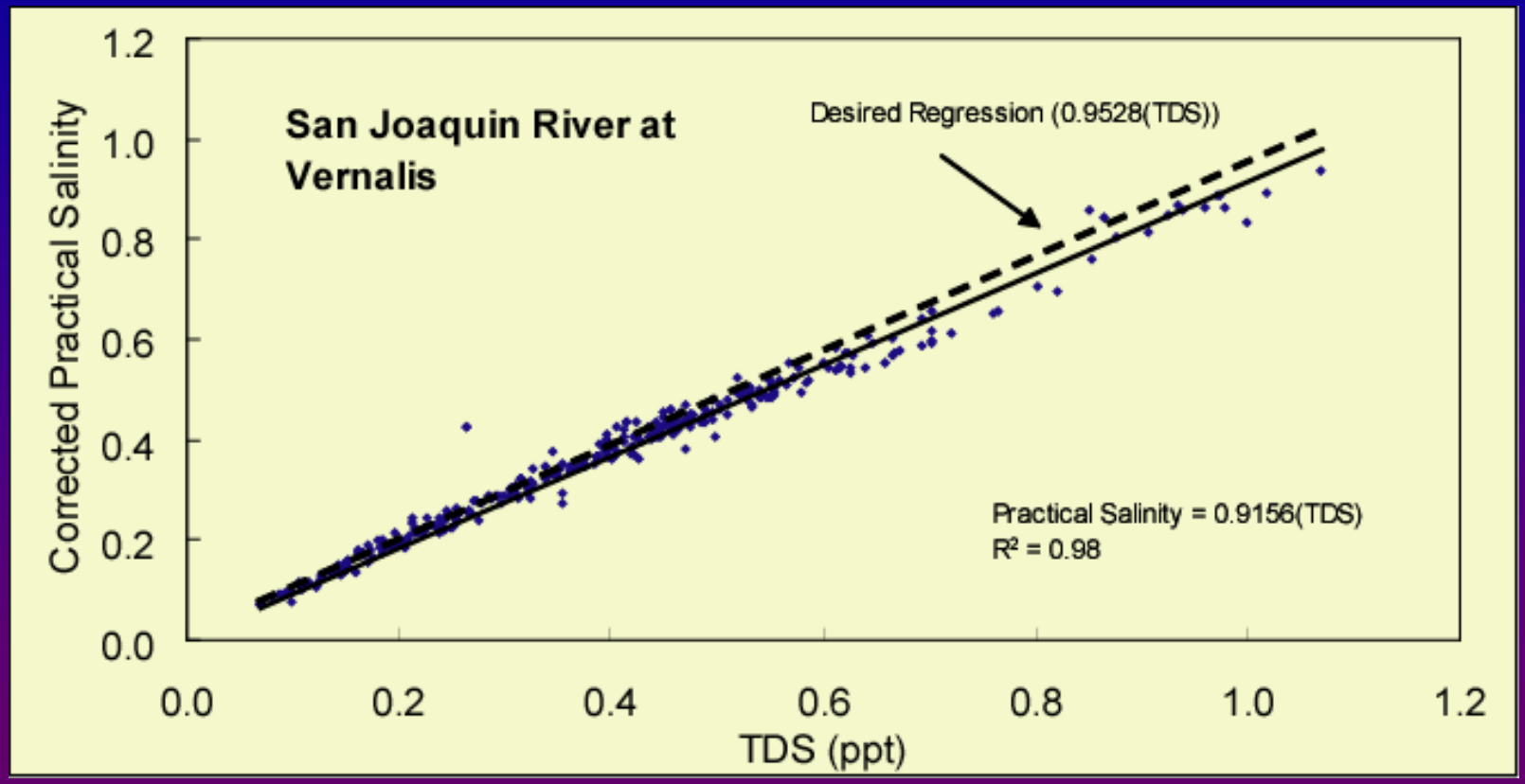
Practical Salinity Corrections

EC	Practical Salinity	Correction
--	0	0
~ 300	0.15	.03 (+19%)
~ 1350	0.67	.05 (+8%)
~ 1825	0.92	0

Corrected Delta Practical Salinity vs TDS



Corrected Practical Salinity at Delta Boundaries



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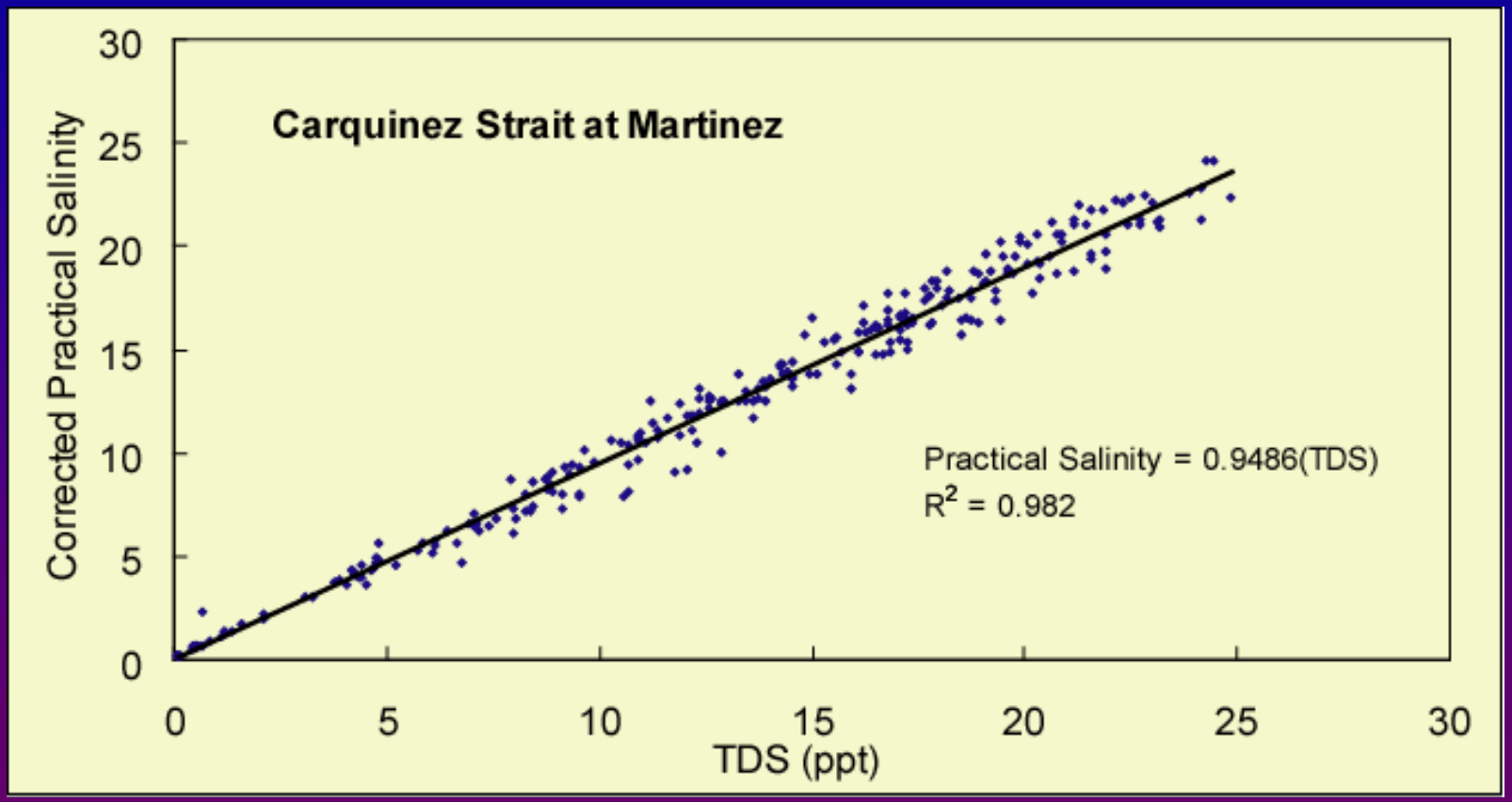

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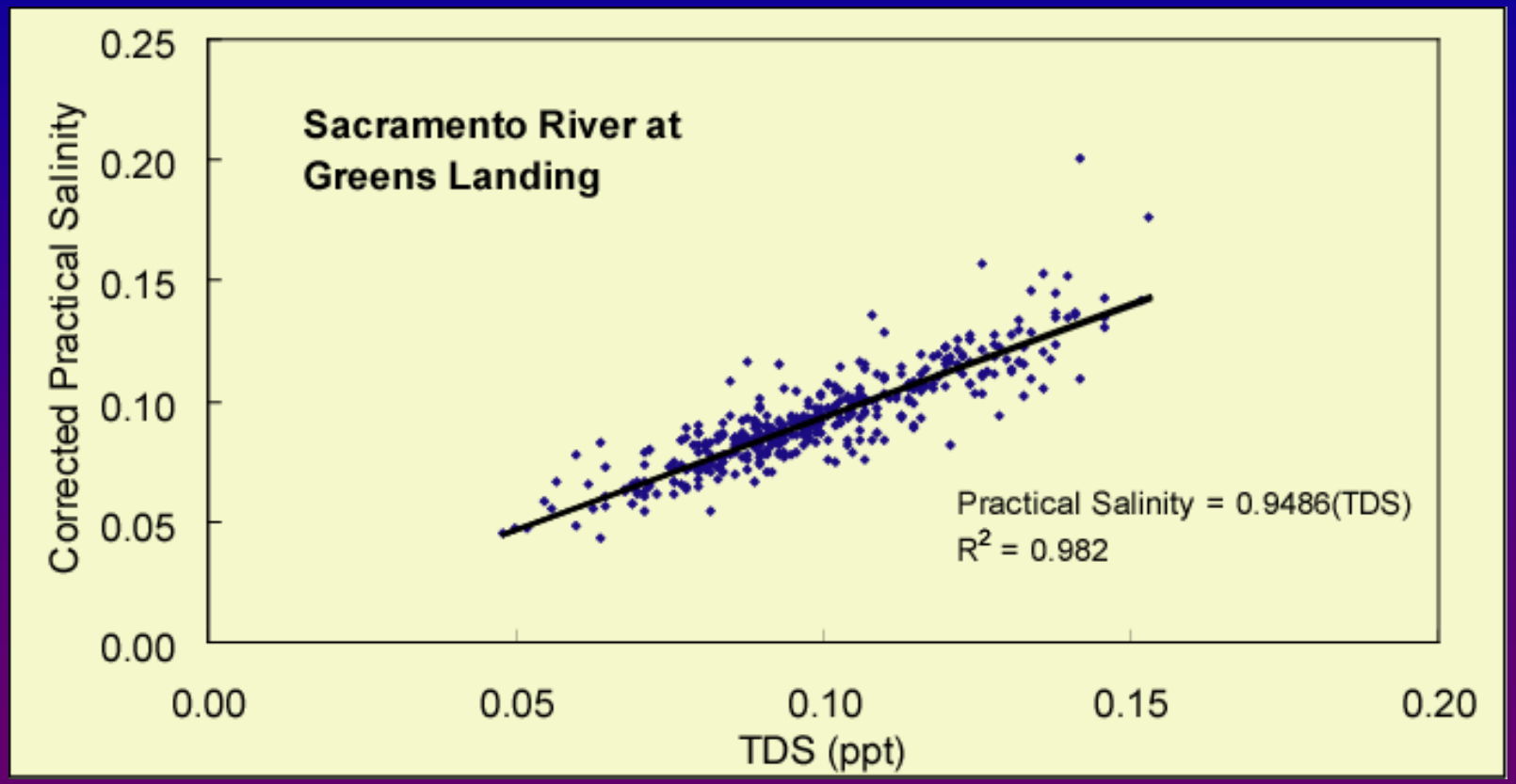
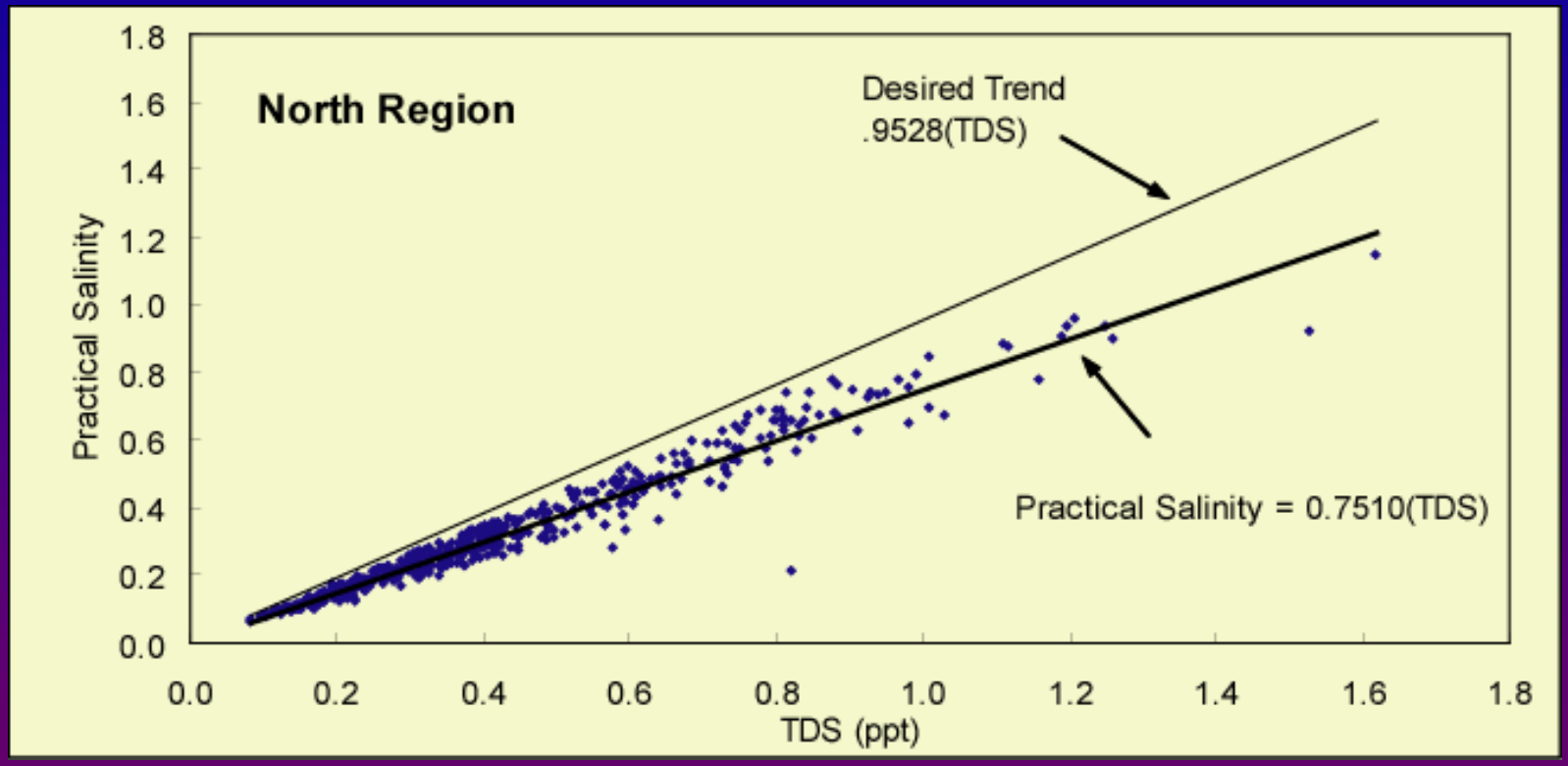
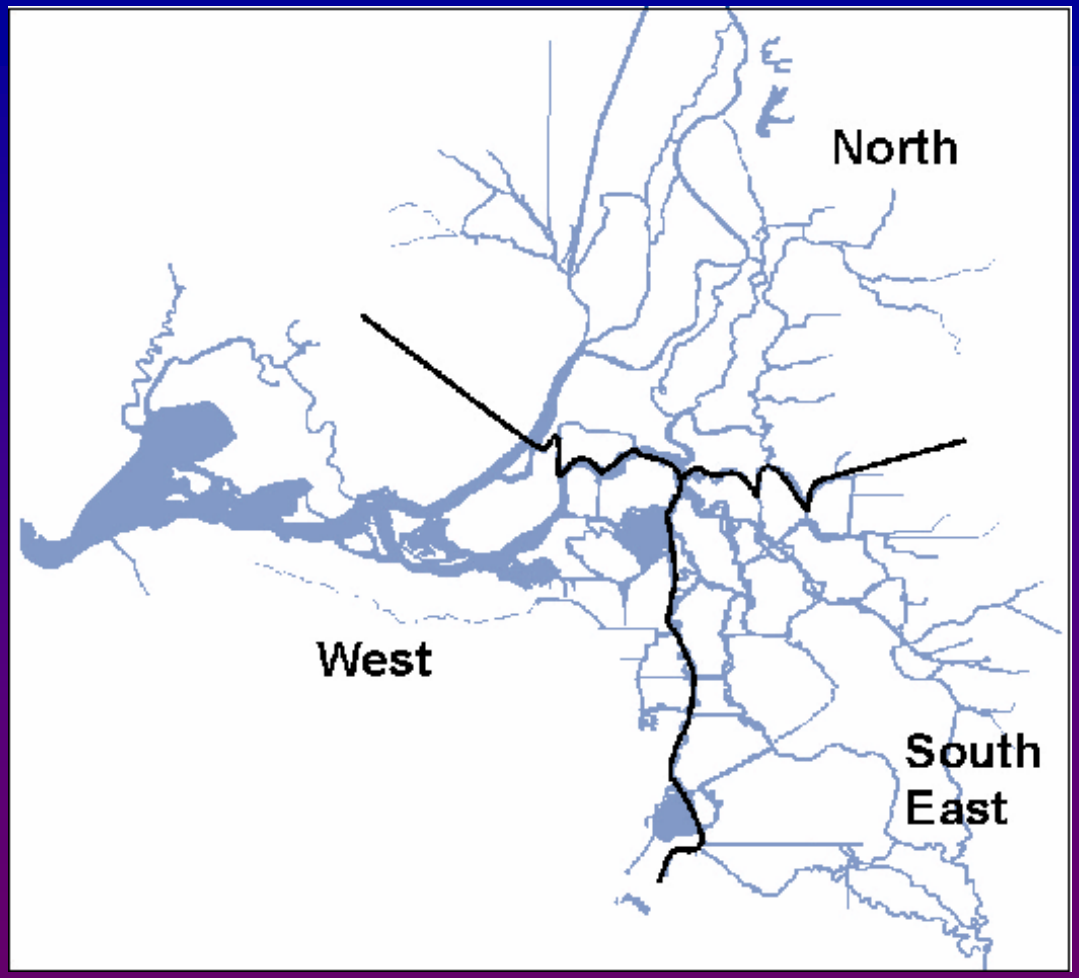


Practical Salinity for Agricultural Drainage



Agricultural Drainage by Region



Possible Calibration / Simulation Scheme

Calibrate to Corrected Practical Salinity

- convert historical EC to corrected PS

Model desired constituent directly

- develop boundary values for constituent

To model EC,

- model Practical Salinity and convert to EC

Or

- model in EC with its own dispersion factors